U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

WASATCH NATIONAL FOREST

ALTA AVALANCHE STUDY CENTER

Miscellaneous Report No. 9

REFORESTATION IN THE AUSTRIAN ALPS

Edward R. LaChapelle
Avalanche Hazard Forecaster
Wasatch National Forest

February 1966

"Those who cannot remember the past
are condemned to repeat it."

--George Santayana

Prologue

In 1880 the first railways were being constructed into the higher reaches of the poorly accessible Austrian Alps. On December 14th of that year, Professor Arthur Freiherr von Seckendorff, Director of Forest Research, addressed a meeting of the Austrian Railway Official's Club in Vienna[1/]. Von Seckendorff dwelt at some length on the effects of the railroad construction on the alpine forests. The railways themselves consumed large amounts of timber for cross ties, and opened a market access which would accelerate logging of forests hitherto protected by their own isolation. He warned of the destructive effects of uncontrolled alpine logging: avalanches, flash floods and erosion. He went on to describe these effects in detail, the means for their prevention, and the methods of reducing damage already done. He emphasized the following:

1. While the basic control measure to hinder erosion from torrents or flash floods (Wildbächer) is to inhibit material transport by flowing water, the ultimate goal to achieve this must be re-establishment of the high-level forests. These forests could be re-established only in stages, beginning with plants to build up the soil which would be followed later by trees.
2. Each local climate and slope exposure would require its own correct species of shrubs and trees. Recognition and selection of these correct species is essential to reforestation.
3. It is absolutely necessary to eliminate grazing animals (cows, sheep, goats) from the reforestation areas.
4. Snow avalanches must be prevented by reforestation and by defense constructions in the release zones.
5. These conservation measures have to be supervised by the government.

Introduction

In the province of Tirol since 1774, unrestricted alpine logging and agricultural practices have lowered the timberline 1300 feet. The forest area has been reduced by one-half.

In the province of Tirol today, there are approximately 2300 avalanche paths which in some way or another affect human activities. Of these, 10 have been subdued by a complete system of defense structures. Construction of defense systems is planned or under way for 20 more. Of these 2300 avalanche paths, approximately two-thirds originate below the climatologically possible (though not necessarily the existing) timberline and are thus amenable to suppression by reforestation.

There is very little Federal land in the Austrian Alps, and only 15% of the forests in all of Austria are state-owned. Almost all of the ground is privately owned by individuals, by groups or by local communities. Ownership of valley lands often carries with it property, timber and grazing rights in the timberline zone and alps. Property maps of the mountainsides illustrate an incredible division of land ownership. More than half the total forest area consists of privately-owned lots smaller than 50 hectares (or 125 acres). Until very recently there has been little control of land and timber utilization, which was left to the discretion of the many individual owners.

In 1947 the Federal Ministery for Land and Forest Economy took the first steps to reverse the long-standing trend of alpine exploitation and increasing avalanche damage. An avalanche section was added to the Section for Torrent Control at Innsbruck. This group began preparation of avalanche maps for Tirol, completing this task in 1951.

Catastrophes during the great avalanche winters of 1951 and 1954 were due not

only to the unusual snow conditions, but also to the long-continued recession of timberline. Avalanches of unusual size opened new paths through the timber which created potential for erosion, future avalanches and further destruction of the forests. These disasters spurred further preventive measures.

The Torrent Control Section in Bregenz prepared an avalanche map of Vorarlberg similar to that of Tirol. A precise vegetation map of Tirol was drawn which illustrated the recession of the forests, current land utilization and areas requiring reforestation. Projects totaling over $3,000,000 were set in motion in four different localities. The objective of these was to double the area covered by forest, triple the timber production, raise agriculture production by 50%, and reduce areas of erosion and avalanche paths to a third of their present size.

It soon became apparent that comprehensive studies necessarily had to precede and accompany successful reforestation of the timberline zone. In 1955 a 16-man research group from the Federal Forest Research Center at Mariabrunn was attached to the Torrent Control Section at Innsbruck and assigned to work on the basic problems of reforestation and avalanche control.

Research on Sub-Alpine Reforestation

The first problem investigated by the research group at Innsbruck was the prospective effects of reforestation on timber production and agriculture. It was shown that agricultural production and forestry revenues could be improved by reforestation and by improvement of alpine farming practices.

With this preliminary question settled, the basic goal became the re-establishment of the alpine forests to their climatologically possible timberline. The over-all objectives of the research were to determine:

1. Natural conditions in the sub-alpine zone.
2. The current disturbance of the natural equilibrium.
3. Ways to restore the equilibrium.

Research was aimed at the sub-alpine zone between the uppermost tree growth, (shrubs, scrub timber) and the lowermost penetration of alpine species into the forests.

From the beginning it was assumed that success could be achieved only by viewing the problem as an ecological whole. The plant communities and the terrain in which they occur had to be treated as a single, inter-reacting entity.

Two lines of attack were adopted. One was investigation in an ecological laboratory ("climate house") erected on the Patscherkofel near Innsbruck. This afforded research under controlled climate conditions into the ecology of plant types. Results from this study were connected with those from the second line of investigation, a field study which produced information on ecology of terrain.

The principal field site was located in the Oetz Valley near Obergurgl, from the valley floor at about 1800 meters altitude to the slopes up above to 2900 meters. This site was chosen because it offered a wide variety of slopes and exposures as well as having a geology and climate representative of the Central Alps. Field

research to date has concentrated on the upper part of the sub-alpine zone, for it is here that reforestating is most difficult.

Two research areas were selected at the Obergurgl site. One was a 1-hectare* clearing in a forest of Siberian pine (Pinus cembra), mean altitude 1920 meters, located in order to study edge effects in the forest. The other was an area of 12.5 hectares in the transition zone from 2,070 to 2,225 meters. Several wooden huts were built to house instrumentation.

The following brief summary of results from the research program to 1963 have been drawn from the two comprehensive volumes published by the Federal Forest Research Center at Mariabrunn[2/].

Solar radiation is much stronger at 2,000 meters than at low elevations. This is particularly true with an overcast sky, for the clouds are not so thick. Snow cover on surrounding slopes can reflect enough sunlight to double radiation intensity. Scattered radiation from summer clouds can briefly raise intensity to levels greater than the solar constant. This intensive radiation in winter causes chlorophyll destruction and damage to tree crowns in the native pines. By contrast, the understory of pine forests in some places is so dark that this is a factor in suppressing reproduction.

Warm zones develop on the slopes in contrast to cold air which forms pools in the valley. In summer these warm zones are in the wooded parts of the slopes, but in winter they lie higher up. Differences of air temperature and humidity are less in a sub-alpine forest than in stands of lower altitudes.

Siberian pine needle temperatures oscillate daily with an amplitude about twice that of air temperature changes. Sub-cooling is severest in winter, the heating greatest in summer; extremes range from $-40^{\circ}C$ to $+40^{\circ}C$. Needle

*1 Hectare = about $2\frac{1}{2}$ acres

damage from freeze-thaw cycles (sometimes several a day) occurs in late winter. Dehydration damage can occur throughout the winter because the needles are free from ice at least part of each day and the evapo-transpiration losses cannot be replaced from the frozen soil.

Soil temperatures in the sub-alpine zone, so important to growing season and soil biology, are determined mainly by ground relief above the upper forest limit. Wind and radiation, both directly and as they affect snow cover, are also important. Three location types for soil temperature are distinguished:

a. Snow-covered, little winter ground frost, little summer surface heating.
b. Deep ground frost resulting from a thin snow cover.
c. Excessive heating in sun-exposed habitats.

The biggest influence of wind is its effect on snow distribution. Snow distribution decides the length of the growing season and thus the chances and rate of growth of reforestation. Trees on bare ridges suffer winter drought damage while parasitic fungi damage those standing in a long-enduring snow cover. Sparse stands of trees create more uniform snow distribution and also inhibit avalanches. During spring thaw the pattern of snow depth distribution stands out very clearly. Maps showing isolines of snow cover duration are the most important single basis of reforestation. There is a correlation between dominant plant types and snow cover duration.

Evaporation is twice as great on wind-exposed ridges as in hollows. Because snow deposition is also minimum on the ridges, these suffer a strong moisture deficiency. Evaporation is greater on shaded windward slopes than on sunny

lee ones. Wind is the dominant factor in determining evaporation.

Technical problems limited measurements of soil moisture, but the few observations showed that wind is a more important determining agent than solar radiation.

Plant communities, soil types, micro-organisms, animal life, and the ecological relation of wind, snow and thaw patterns all show definite interrelationships.

Natural reproduction of Siberian pine depends on relation of available seed quantity to the activity of its only natural disseminating agent, the thick-billed nutcracker (Nucifraga carupcatactes). It also depends on certain plant types which provide suitable seed beds, and on the depth and duration of the snow cover.

Artificial introduction of Siberian pine should be by transplanting nursery-grown seedlings at least four years old. Planting has to be done in holes or mounds. The planting holes are dug the previous summer to improve the soil, the trees are planted 5000 to the hectare, and the losses are made up after the first year. Losses up to 50% are expected for the first year, but this figure drops to 1-5% for trees five to eight years old. Ultimate density of 3000 trees per hectare is sought. It is not yet known whether this density will suppress all avalanches.

Measurements of assimilation and respiration of young Siberian pines show a strong annual variation in these quantities. Autumn assimilation is only half that of spring for similar amounts of solar radiation, and drops much lower prior to formation of winter ground frost. The carbon dioxide balance is negative

in winter, but assimilation starts again with thaw although the tree may still be covered with snow. Assimilation shows a sharp rise late in spring when daily average needle temperature exceeds $10^{o}C$, only to fall off again when sprouting starts late in July. A substantial difference between amount of carbon dioxide absorbed and the amount of mass added by growth has been observed but not yet explained.

Investigation of temperatures and freezing point of Siberian pine needles shows annual variation of frost hardiness. Old trees are much more frost-resistant than young ones, and young trees from nurseries may be easily damaged if snowfall does not protect them from frost.

The greatest damage to Siberian pines is caused by low-temperature parasitic fungi, mainly the snow-blight, which is most effective in zones of long-lasting snow cover. The maximum damage occurs in just those plant communities which offer the most favorable seed beds for natural pine reproduction, hence the maximum winter snow depth takes on a critical importance. This species of tree is not suitable for reforestation with present techniques in areas of persistent deep snow cover.

Extensive wind tunnel and field tests with wind-deflection structures (snow fences, kolktafeln, jet roofs, etc.) have developed techniques for extending areas susceptible to reforestation. From the standpoint of plant growth, these structures are used to equalize snow distribution, preventing deep accumulations and depositing snow on otherwise bare sites exposed to wind scour. From the standpoint of avalanche prevention they break up the mechanical continuity of slab formation. In essence they perform artifically these two functions of a forest cover and allow reforestation to proceed unhindered by avalanches

and by gross inequalities in snow deposition.

The successful reforestation of wasteland or soil long-unused for tree-growing can only be achieved when the development of fungi (mycorrhizal mycelium) is promoted by artificial measures. This can most conveniently be done by soil inoculation in nurseries at the same time as seeding or transplanting.

Influence of these various factors on reforestation has been graphically summarized by H. Aulitzky in a complex "ecogram" which serves as a field guide to terrain classification and the appropriate steps in re-establishing the subalpine forest cover.

The methods and techniques devised by this research program are now being put into practice. The first extensive application has been in Ziller Valley, one of the major tributaries to the Inn Valley southeast of Innsbruck.

The Ziller Valley program aims to revise completely the whole ecology and economic utilization of the timberline zone. It is a pilot program which eventually will be extended to the rest of the Austrian Alps. Initiation of this revision has not been easy, for there was strong political and economic opposition from the mountain farmers, who are notably conservative and suspicious of change everywhere in the Alps. Political and psychological evolution have thus become just as important as a solution to the technical problems. Obstacles to starting the program have been formidable, but its initial success in the Ziller Valley will simplify the job of selling reforestation elsewhere.

Instead of ranging freely over the alps as they have done for centuries, dairy herds are now confined to specific grazing areas accessible by newly-built roads and served by central milk stations. These grazing areas are carefully managed for grass and water. Yield from the dairy herds is higher in these managed areas

than from the overgrazed alps. They produce just as much or more milk as the much larger areas formerly given over to uncontrolled grazing. Cheese production, formerly conducted at scattered mountain sites, has been moved to a more efficient central valley station. The whole dairying industry is more efficient and the cost to the farmer lower. The remaining timberline areas, freed from destructive grazing, are now given over to reforestation. Erosion control measures are also being introduced. Trimming and uncontrolled logging in the timber-producing forests has been eliminated. Forestry is now under the supervision of a certified forest manager instead of being left to the local farmers.

This Ziller Valley project embraces an area of 100 square kilometers. It aims to eliminate erosion from 16 stream beds and to eliminate by reforestation 9 avalanche paths. Improvements in forestry have increased immediately the economic yield from lumbering by $9,500 annually. With eventual restoration of the full forest cover when timberline is raised from 1,600 to 2,000 meters, this gain is expected to rise to $30,000 annually. Initial cost of the whole project was set at 1.4 million dollars, but the economic benefits to residents of the valley has encouraged them to contribute to the cost, especially road construction, and the estimated cost has now been lowered to 0.8 million dollars.

The rapidity with which the Austrian Government has been able to establish successful reforestation in difficult climate and terrain is impressive. Within ten years from the start of the research program, a clear understanding of the ecological problems has been attained, basic practices of alpine farming and forest industry have been revised, and successful reforestation is under way. Research from the start was aimed at practical applications rather than theoretical principles. The rapidly growing avalanche hazard compelled haste; practical preventive measures had to accompany rather than follow research. The Austrian scientists attribute success in this speedy development of the science of sub-alpine forestry to the explicit adoption of a research program based on causative rather than statistical analysis.

In summary, reforestation today in the Austrian Alps embraces the following principles:

1. Re-establishment of the alpine forests must raise the timberline to the climatologically possible maximum. This is a slow process which begins with restoration of soil and plant cover and culminates with planting of trees. Erosion control is a necessary adjunct to this reforestation.
2. Sub-alpine forestry differs markedly from that at lower altitudes. A comprehensive study of terrain, microclimate and local plant types must precede the selection of techniques and species for rebuilding soil and forest.
3. It is absolutely necessary to eliminate grazing animals from the reforested areas.
4. While avalanche defense facilities are essential to protect critical

sites and often to initiate reforestation, the only technically and economically feasible method of widespread avalanche control is restoration of timberline forests and the consequent elimination of avalanche paths.

5. These measures are the responsibility of the provincial and federal governments. The critical conservation problems of the sub-alpine zone demand a systematic and coordinated solution, guided by a single plan. This cannot be achieved alone by the many and diverse economic interests in the timberline zone.

These principles have a familiar ring. They echo with remarkable precision those enunciated by von Seckendorff in 1880. The Austrians waited 75 years to heed his words, a delay whose cost has been formidable. In the the province of Tirol alone since 1880

--the amount of land which can support cattle grazing has <u>diminished by half</u>,

--economic yield from agriculture and forestry has <u>diminished by two-thirds</u>,

--the area of torrent erosion and avalanche paths has <u>multiplied fourfold</u>.

The price that still must be paid is also enormous. The cost of necessary reforestation in Tirol alone is estimated at $20,000,000. For all of Austria this figure is quadrupled, a staggering sum for a nation with an annual budget a little over two billion dollars.

One fact stands out from this short review. The basic requirements and necessity for sub-alpine reforestation were clearly understood 85 years ago. The successful modern research program has solved many technical problems, but it has introduced no new principles. The failure to prevent exploitation and damage of the timberline zone was not due to a lack of knowledge. It was an economic and political failure to act on knowledge already available. This is a marked contrast with France, where alpine forests have been protected for a century, and with Switzerland, where a federal law enacted in 1876 forbade henceforth any reduction in the total area of Swiss forests.

The Austrian experience stands as an instructive example for all of us engaged today in administration and use of timberline lands. Altitude, plant communities, terrain, geology and microclimate differ widely in this zone from one continent and one mountain range to the next, and from one climate to another. But everywhere the sub-alpine zones share a timberline forest equilibrium which, once destroyed, can be restored only at great effort and expense. The Austrians might be excused for ignoring their prophets in 1880, when principles of conservation were poorly formulated and often ignored, but such an excuse will not stand elsewhere today.

The lessons to be learned from the Austrian Alps are especially pertinent to the United States Forest Service at a time when planned utilization of American timberline lands and forests has only just begun, and when the pressure of lumbering and especially recreation on these areas will increase rapidly in the future. The judgement of those who will look back on today from the vantage point of another half-century will hardly be charitable if these

lessons are ignored.

On paper at least, the prognosis is favorable. Multiple-use policy recognizes the special character of the crest zones within the National Forests and sets guidelines for their maximum disturbance. The Intermountain Region Multiple Use Management Guide, for example, says this about the crest zone: "The ecologic balance is delicate; hence, protection of watershed values is the most essential consideration in all uses and activities." But, while the guiding principles are understood (the Austrians understood the principles, too, three-quarters of a century ago), their application sometimes is uncertain. Today we stand in pressing need of more research on the kinds and amounts of use our American timberline zones can sustain without damage, and the dissemination of the knowledge among administrators responsible for the management of these zones.

There are many instances in the U. S. mountain west where timber-cutting at high elevations during the early mining era resulted in new avalanche paths. Fire and overuse by livestock have also contributed to this situation. More serious today are the problems raised by winter sports developments, road construction and clearing for utility lines. Any such activity which diminishes or alters sub-alpine vegetation requires the most careful and cautious planning, which, as the Austrians have learned, cannot be left to the sole concern of a private profit economy. The current importance of this requirement, as well as the problems raised by inadequate planning, have been illuminated by unusual avalanche activity at a number of ski areas and above highways in the winter of 1965/66, especially in the Pacific Northwest. A recent proposal for

a winter-summer recreation development which would invite several million visitors a year to a sub-alpine basin country also raises the question of whether mountain soil and vegetation can withstand this mass-type use.

Constructive Forest Service policy intended to meet such problems is illustrated by current work in Utah aimed at the comprehensive planning for a National Forest crest zone involved in, among other things, the State's bid for the 1972 Winter Olympics. This zone in any case may eventually become part of a large winter sports complex. Here the critical aspects of geology, soil, watershed, timber cover, logistics and avalanches are all receiving consideration to assure a long-range development plan which will coordinate and protect multiple use values of this crest zone.

The basic knowledge for adequate administration of our crest zones in the United States is clearly at hand, augmented by past and present experience in such comparable areas as the Austrian Alps. But even so, questions are being raised today about such problems as cutting timber in subalpine zones where this may augment snow avalanche activity. Von Seckendorff 85 years ago could have warned of the problems such cutting will raise. While we do have a plainly stated crest zone policy, the responsibility for its wise execution rests with today's administrators of public and private lands. Austria's experience will remind them that we are wiser to accept Santayana's dictum than to try to demonstrate it.

References Cited

1/von Seckendorff, Arthur, Frh., Ueber Wildbach und Lawinen-verbauungen, von Gebirgshangen und Dammboschungen. 2. Aufl. Faesy u. Frick, Wein, 1881, 22 p.

2/Mitteilungen der Forstlichen Bundes-Versuchsanstalt Mariabrunn, Oekologische Untersuchungen in der Subalpinen Stufe. Teil 1 (Heft 59), 1961, pp. 1-432; Teil II (Heft 60), 1963, pp. 433-887.